Distributed Crew Interaction with Advanced Life Support

March 2003

Johnson Space Center

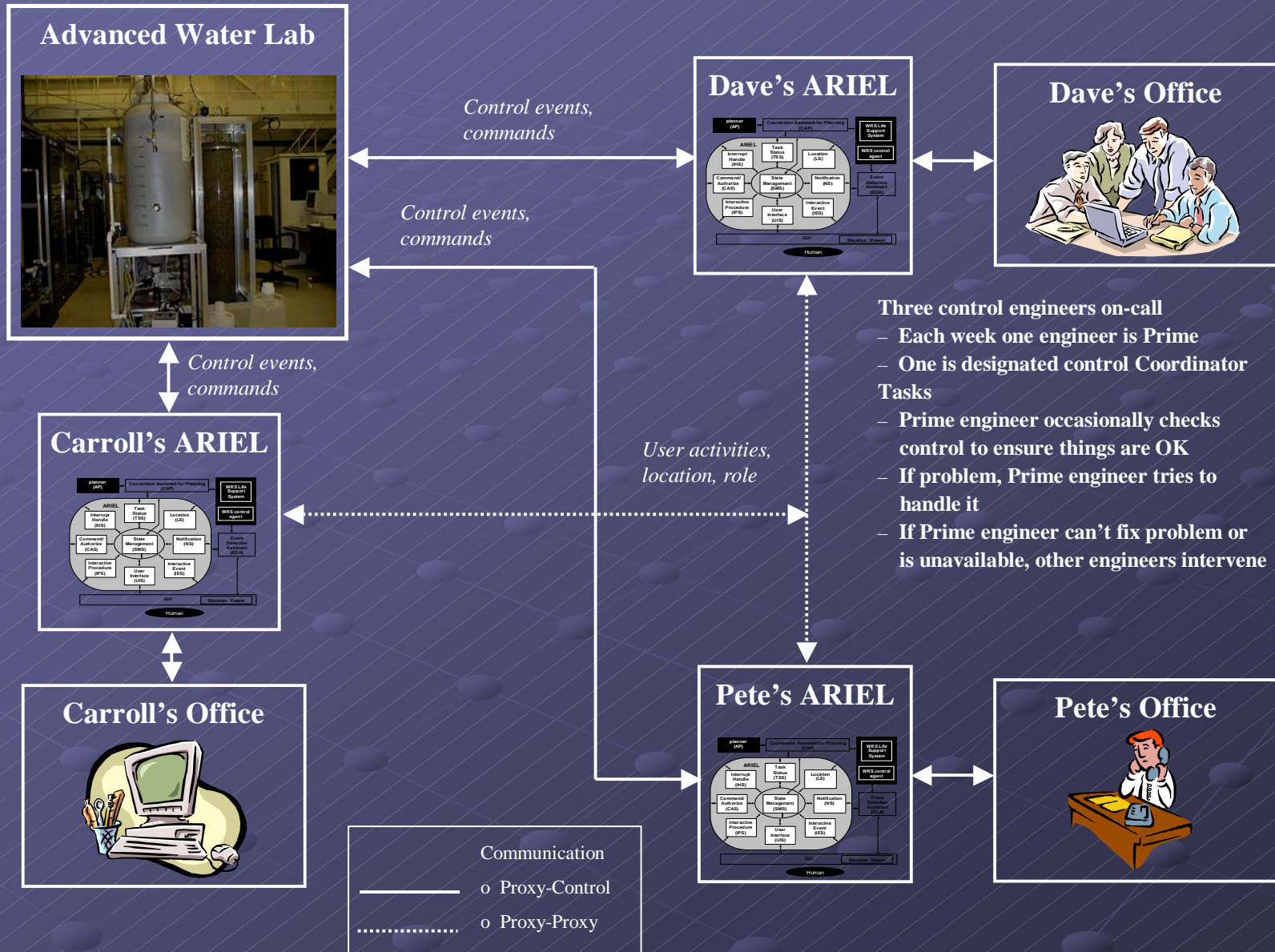Debra Schreckenghost

Cheryl Martin

Pete Bonasso

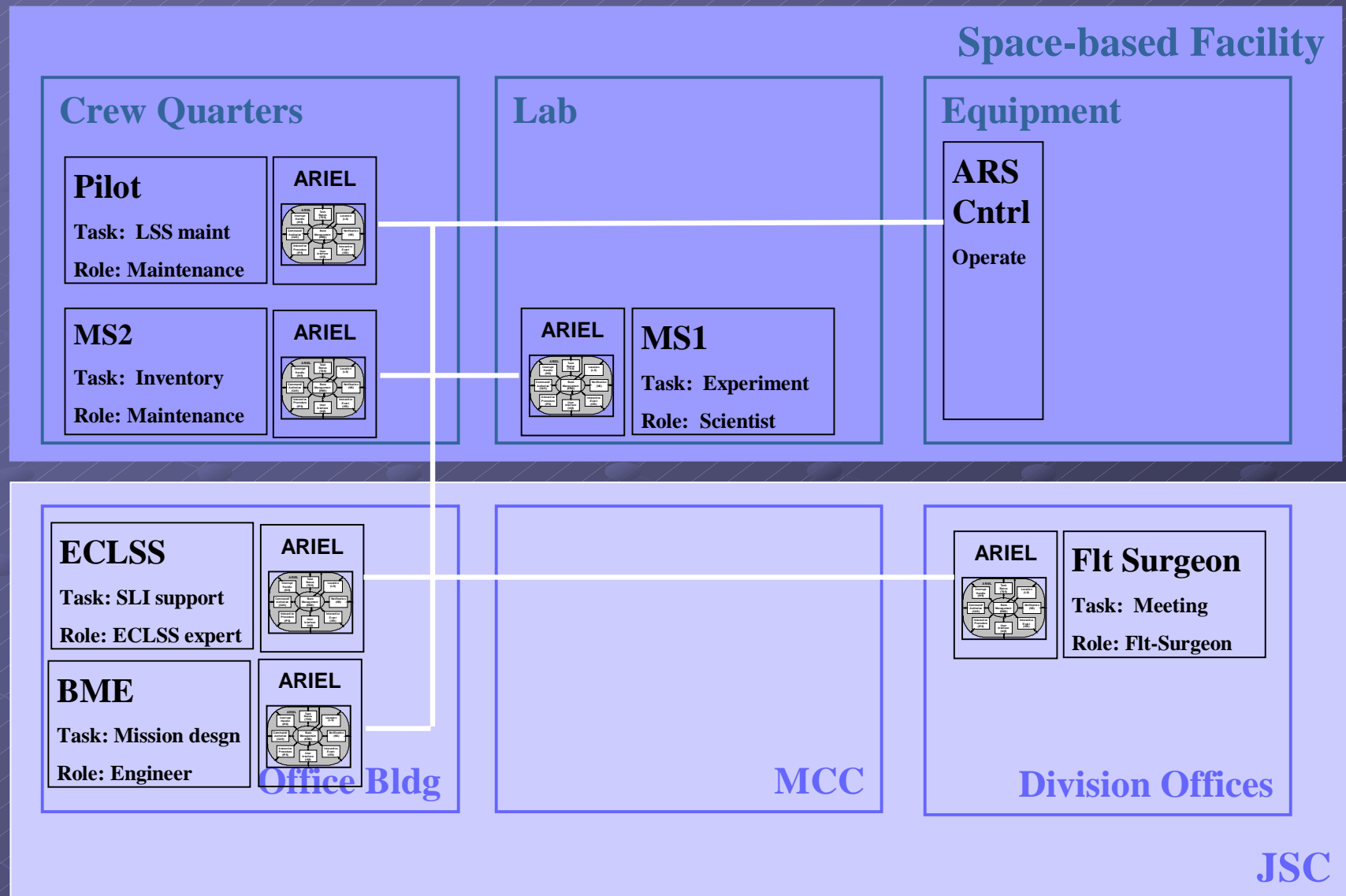David Kortenkamp

Tod Milam

Carroll Thronesbery

DCI Project

- Objective: aid user in working as part of a team of distributed humans and automated control agents to perform remote operations safely

- Approach: provide proxy agents for each user that facilitate this interaction
  - Agents are called Attentive Remote Interaction and Execution Liaison (ARIEL) agents
  - ARIEL agent serves a single user by providing services to help achieve goals according to organizational policies and protocols
  - Services are defined independent of a specific human but are configurable by the user

OPS Analog: Advanced Water Lab

Advanced Water Lab

Control events, commands (Advanced Water Lab ↔ Dave's ARIEL)

Control events, commands (Dave's ARIEL → Advanced Water Lab)

Control events, commands (Advanced Water Lab ↔ Carroll's ARIEL)

Dave's ARIEL

Dave's Office

Three control engineers on-call
- Each week one engineer is Prime
- One is designated control Coordinator Tasks
- Prime engineer occasionally checks control to ensure things are OK
- If problem, Prime engineer tries to handle it
- If Prime engineer can't fix problem or is unavailable, other engineers intervene

Carroll's ARIEL

User activities, location, role

Pete's ARIEL

Carroll's Office

Pete's Office

Communication
- o Proxy-Control
- o Proxy-Proxy

How does ARIEL Agent Assist OPS?

- Facilitate user interaction with control agents and other humans to perform tasks associated with assigned roles in an operational group

  - Communicating in an organizational context
  - Coordinating group activities
  - Tracking human location
  - Summarizing complex

    situations
  - Aiding coordinated,

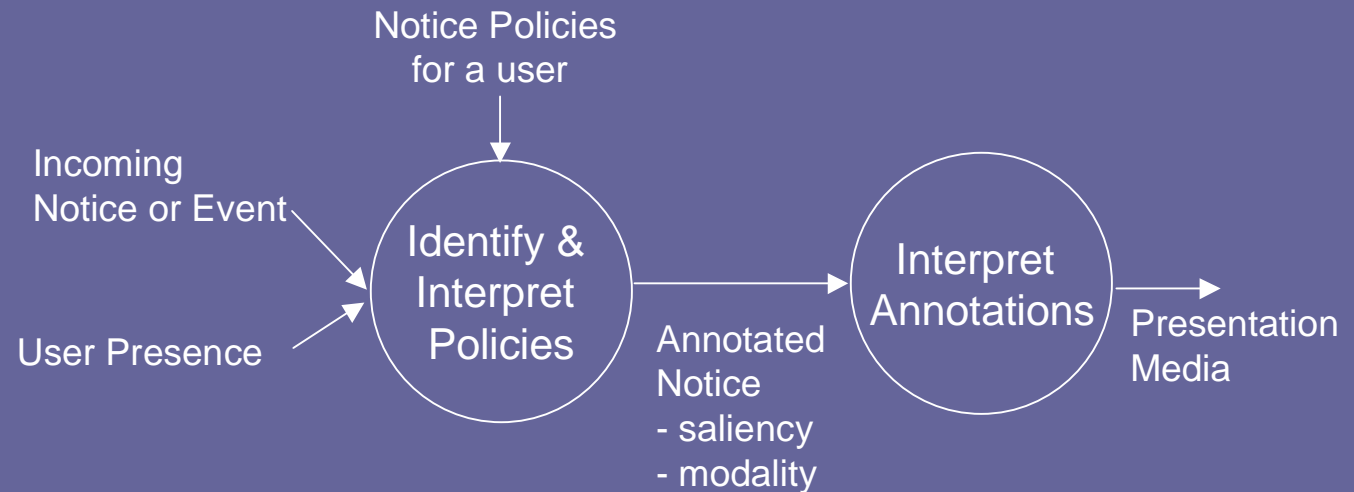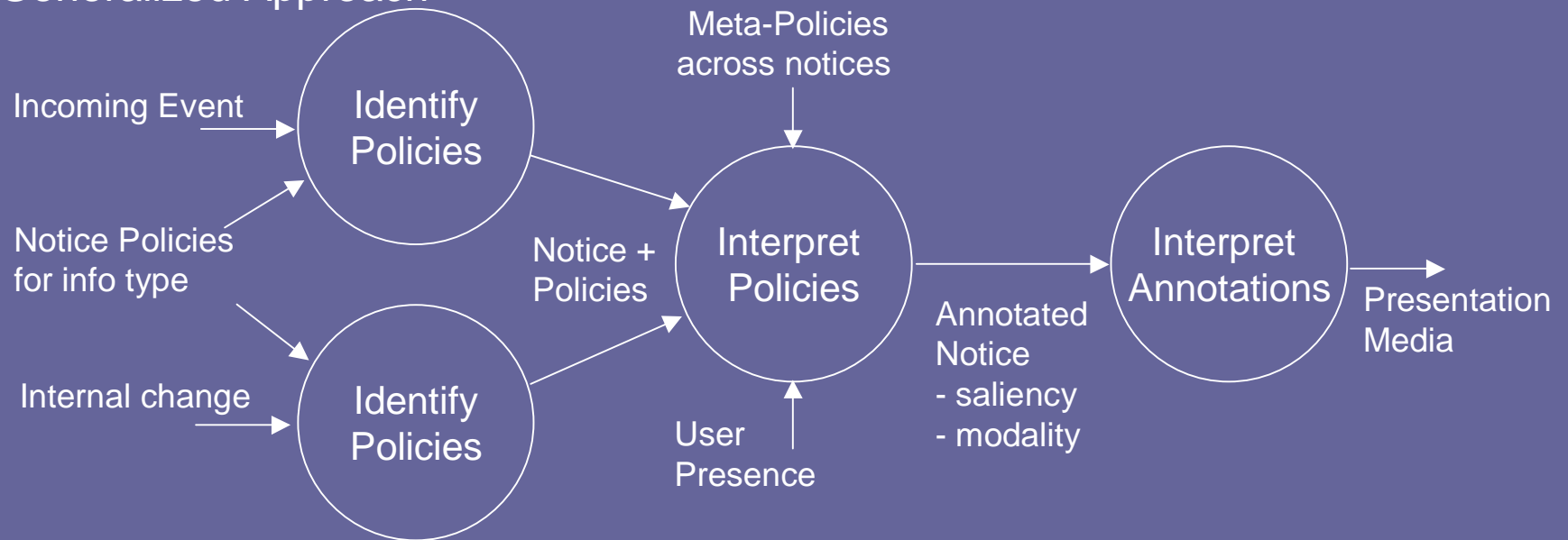   distributed commanding

    within group
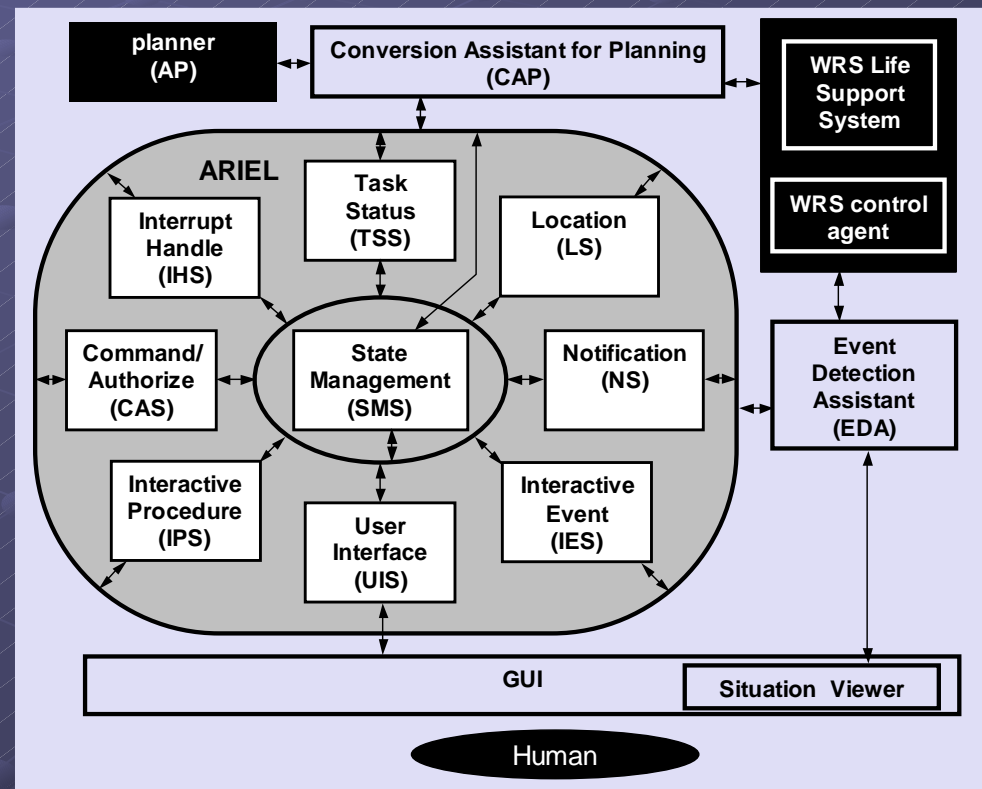
Communicating in Organizational Context

- ARIEL notifies user of control events & agent notices based on group requirements & personal preferences
  - Policies for notification are defined for each role a human takes
  - As roles change, policies in effect update automatically
  - Initial implementation of policy-based notification addressed notification of incoming events
  - Generalize our approach to notification for policy-based, integrated information presentation
    - Any ARIEL Service: When a change occurs requiring notification of the user (e.g., event, deadline passes), determine which notice policies hold and pass notices with policies to UI Manager
    - UI Manager: Interpret these policies across all events using meta-policies that assign saliency and modality annotations
    - Presentation Managers: Interpret the annotations for integrated presentation within a medium

Initial Approach

Notice Policies
for a user

Incoming
Notice or Event

User Presence

**Identify &
Interpret
Policies**

Annotated
Notice
- saliency
- modality

**Interpret
Annotations**

Presentation
Media

Generalized Approach

Incoming Event

**Identify
Policies**

Meta-Policies
across notices

Notice Policies
for info type

Notice +
Policies

Internal change

**Identify
Policies**

**Interpret
Policies**

User
Presence

Annotated
Notice
- saliency
- modality

**Interpret
Annotations**

Presentation
Media

Agent Communication

- Communication Management Service: defining a new service to support human/multiple agent communication
  - Inform an agent: Information passed from one agent to other agents
    - Domain events: control agent to human
    - Agent-initiated events: human to human, human to support agent (e.g., IBRA), support agent to human
  - Query an agent: Structured interaction that links the query from requesting agent to the answer from responding agent
  - Chat with an agent: Query requesting to communicate, followed by unstructured information exchange

- Modeling considers the agent communication standards define by the Foundation for Intelligent Physical Agents (FIPA)

    http://www.fipa.org/repository/aclspecs.html

Coordinating Group Activities

- DCI manages user tasks based on group roles and coordinates group actions
  - Activity planner builds centralized group plan, assigns tasks, and marks tasks complete
  - ARIEL agent tracks completion of its user's activities and provides assessment to planner
- Status
  - Implementing strategy for handling tasks not completed on schedule
    - Unless scheduled task is critical, assume done at planned time
    - At the end of the day, user reviews daily schedule and identifies which tasks did not complete
    - Tasks not completed and not canceled are replanned
  - Extending the Conversion Assistant for Planning to initiate replanning
    - Changes in crew health
    - Changes in flight rules
    - System anomalies not requiring immediate action

Tracking Human Location

- ARIEL agent tracks the location of its user
  - Maps location readings to physical location ontology
    - Track machine locations where users login/out of ARIEL
  - Translates location and online/offline information to human presence ontology
  - Status: adding additional location readings
    - GPS sensor on handheld for tracking outside buildings
    - RF-based tracking
      - Mobile platform measures signal strength from wireless access points
      - Measurements are matched to a signal strength map to triangulate the current position within a building
        - Nearest neighbor technique (Bahl, P. and V. N. Padmanabhan, 2000)
        - Combine signal strength with Bayesian modeling (Castro, P., P. Chiu, T. Kremenek, and R. Muntz , 2001)

Summarizing Complex Situations

- DCI environment captures complex situations for review
  - Situation capture using Event Detection Assistant (EDA) (Fitzgerald, W., R. J. Firby, & M. Hanneman. 2003).
  - Situation viewed using ARIEL agent
- Status
  - Defining the information required to specify a control situation (Endsley, 1996; Christoffersen, Blike, and Woods, 2002)
    - Collected in real-time
      - Data changes from controlled system
      - Events recognized in data and relationships among events
        - Primitive events and complex events built from primitive events
    - Defined apriori
      - Parameter data definitions (e.g., value range, units, expected values)
      - Patterns and conditions used to recognize events
  - Supporting review of situation from different perspectives
    - Utilizing event hierarchy to investigate the situation
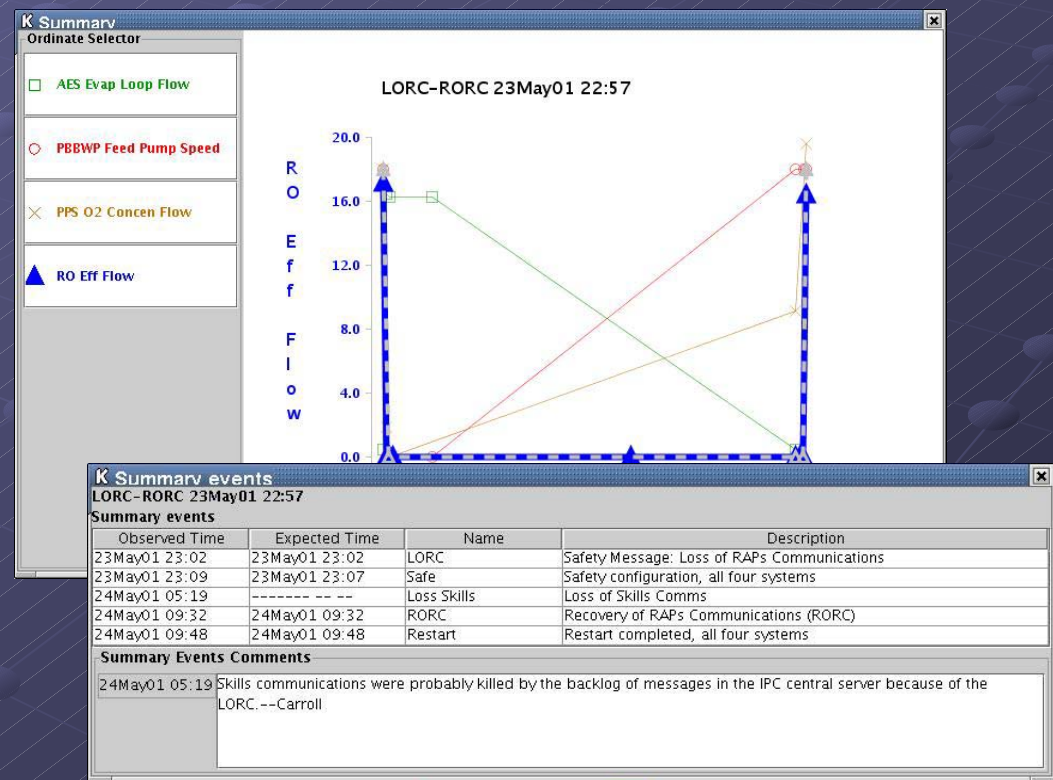   - Relating system changes to tasks performed

Perspectives for Situation Review

System Hierarchy

Crew Life Support
- ARS
  - VCCR
  - CRS
  - OGS
- WRS
  - BWP
  - RO
  - AES
  - PPS
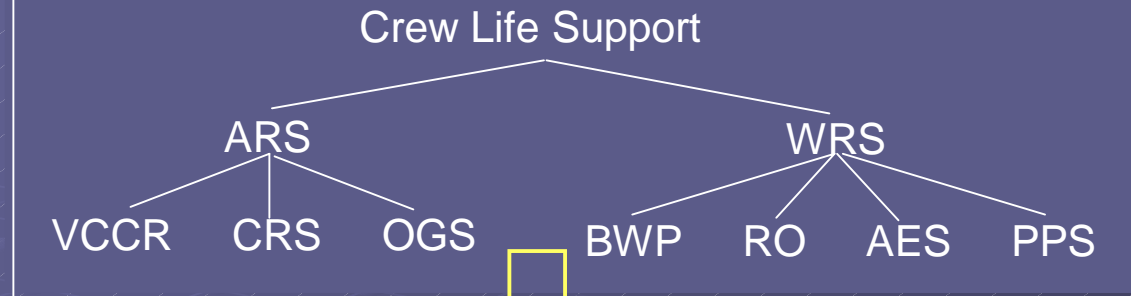
Event Hierarchy

— Loss of communication

— Safety configuration all systems
- — BWP safed
- — RO safed
- — AES safed
- — PPS safed

— Recovery of communication

— Restart all systems
- — BWP started
- — RO started
- — AES started
- — PPS started

Summary — Ordinate Selector

- ☐ AES Evap Loop Flow
- ⬡ PBBWP Feed Pump Speed
- ✕ PPS O2 Concen Flow
- ▲ RO Eff Flow

LORC-RORC 23May01 22:57

R O Eff Flow: 20.0, 16.0, 12.0, 8.0, 4.0, 0.0

Summary events

LORC-RORC 23May01 22:57

Summary events

Observed Time	Expected Time	Name	Description
23May01 23:02	23May01 23:02	LORC	Safety Message: Loss of RAPs Communications
23May01 23:09	23May01 23:07	Safe	Safety configuration, all four systems
24May01 05:19	------- -- --	Loss Skills	Loss of Skills Comms
24May01 09:32	24May01 09:32	RORC	Recovery of RAPs Communications (RORC)
24May01 09:48	24May01 09:48	Restart	Restart completed, all four systems

Summary Events Comments

24May01 05:19 Skills communications were probably killed by the backlog of messages in the IPC central server because of the LORC.--Carroll
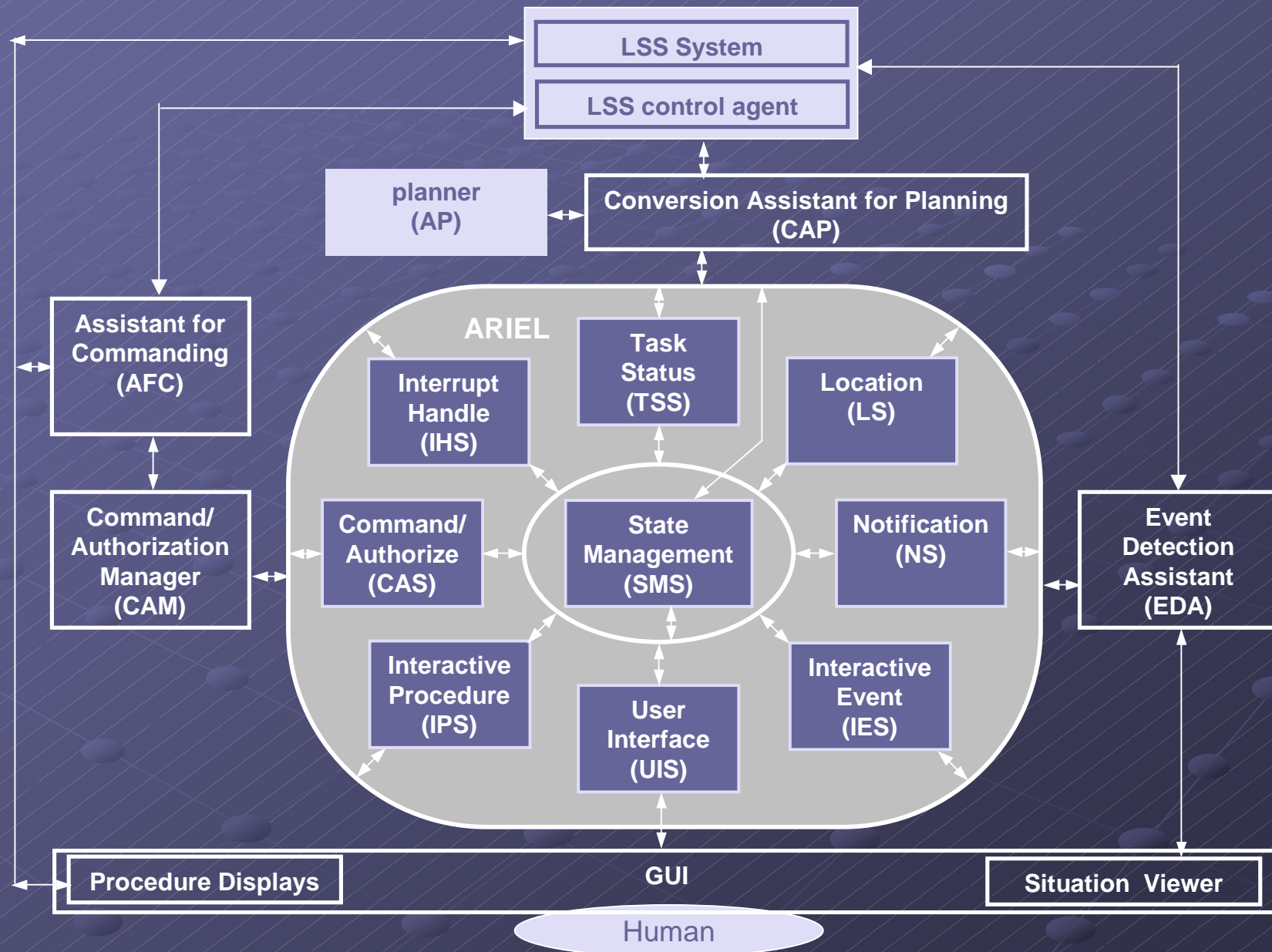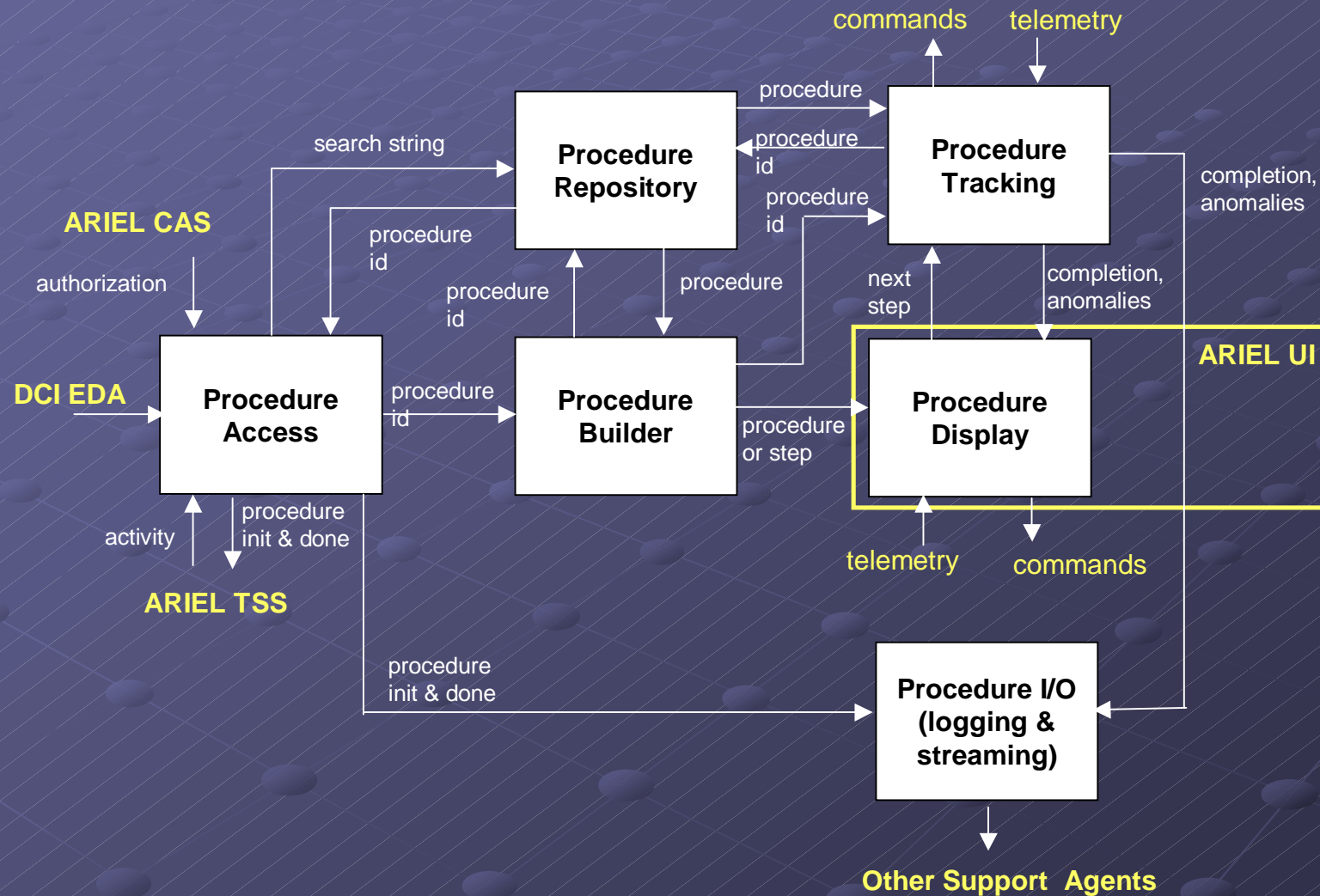
Aiding Distributed Commanding

- ARIEL agent will assist humans in commanding systems normally managed by automated control agents
  - Checks credentials of user based on assigned roles
  - Detects and resolves potential command conflicts
    - Encode policies for command authorization based on model of how procedures affect the controlled system
    - Initially, implement authorization policies for nominal operating configuration
    - Later, adjust authorization policies for degraded mode operating configurations
  - Reconfigures automated control agent for manual commanding
    - Avoid conflicts with automated procedures
    - Reduce vulnerability to harm during manual commanding
  - Supports the execution of manual procedures
    - Find the right procedure (e.g., scheduled, triggered, searched)
    - Represent and present procedures for human use
    - Track execution of procedure steps

DCI Architecture with Commanding

LSS System

LSS control agent

planner (AP)

Conversion Assistant for Planning (CAP)

Assistant for Commanding (AFC)

Command/ Authorization Manager (CAM)

ARIEL

Interrupt Handle (IHS)

Task Status (TSS)

Location (LS)

Command/ Authorize (CAS)

State Management (SMS)

Notification (NS)

Interactive Procedure (IPS)

User Interface (UIS)

Interactive Event (IES)

Event Detection Assistant (EDA)

Procedure Displays

GUI

Situation Viewer

Human

Preliminary Design for Manual Commanding
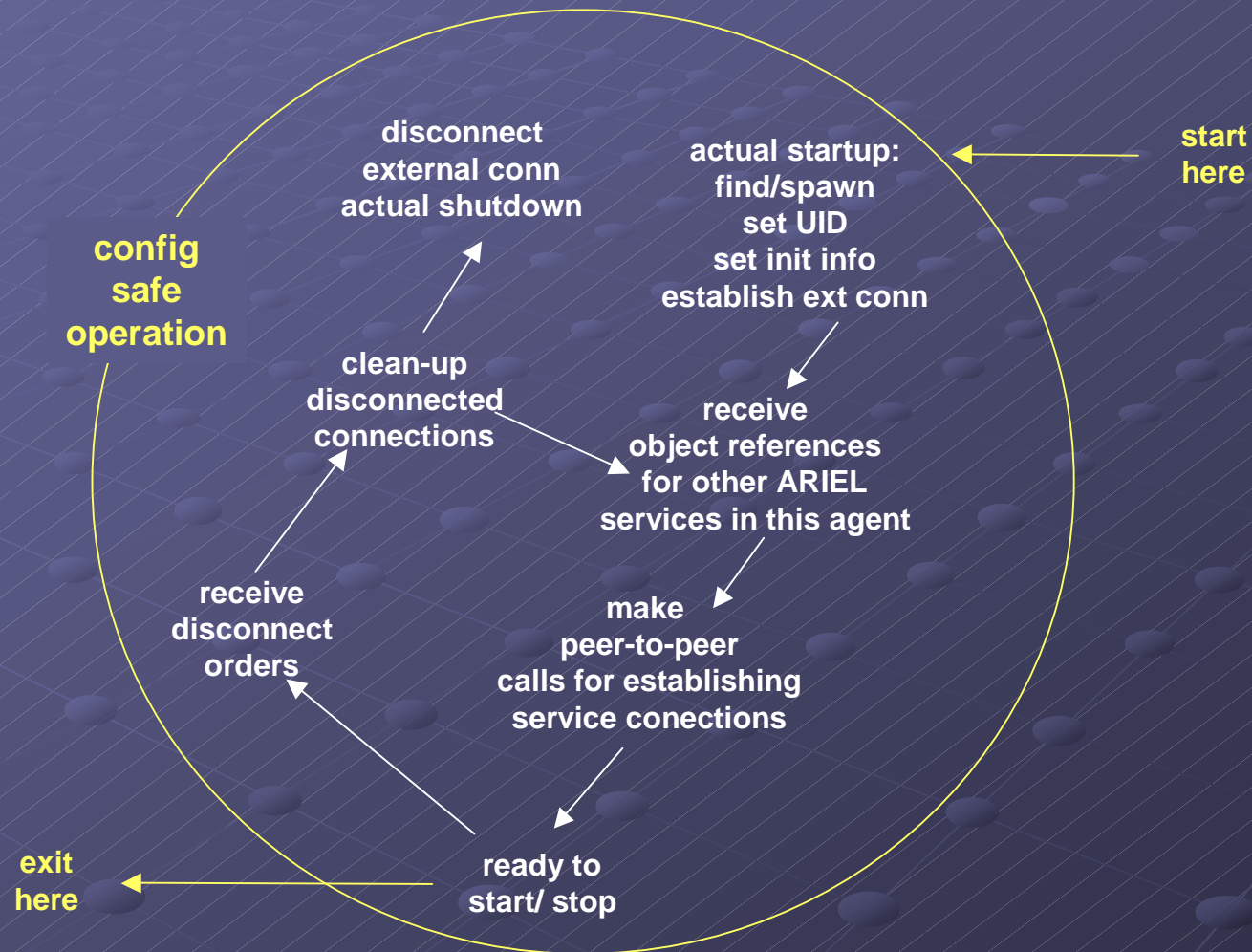
Lesson: Designing for Reconfiguration

- Requirements for reconfiguration
  - Apply ARIEL to applications other than crew liaisons (e.g., support for ground controller liaisons)
  - Replace existing services with alternative capabilities
  - Add new services
- Changes supporting reconfiguration
  - Execute ARIEL agent with a subset of the available services active
  - Shutdown and restart one of many ARIEL services while running, based on a reconfiguration state model that configures for safe operation during these transitions
  - Streamline the management of ARIEL agent and services for easier use by us and for reuse by others

Reconfiguration State Model

disconnect
external conn
actual shutdown

actual startup:
find/spawn
set UID
set init info
establish ext conn

start
here

config
safe
operation

clean-up
disconnected
connections

receive
object references
for other ARIEL
services in this agent

receive
disconnect
orders

make
peer-to-peer
calls for establishing
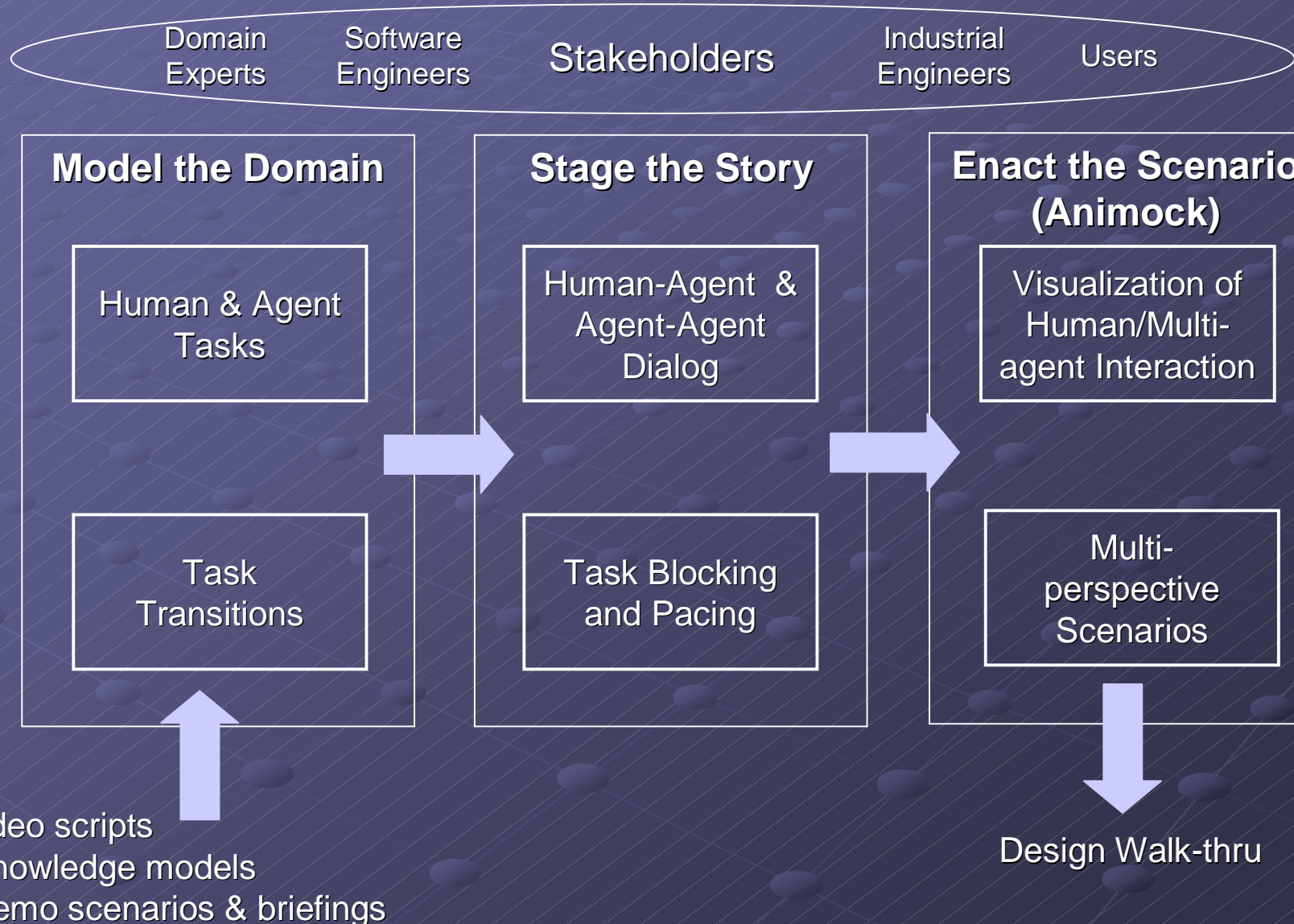service conections

exit
here

ready to
start/ stop

Techniques for Design of Multi-agent Systems

- Investigating the use of animated mockups to aid designers of human/multiple agent interaction (Roesler, Feil, Woods, Puskeiler, Tinapple, 2001)
  - Illustrate mutliple, simultaneous perspectives
  - Visualize human-agent and agent-agent interaction
  - Detect problems in task pacing, agent interaction, etc.
- Status
  - Visited Cognitive Systems Engineering Lab (CSEL) at OSU
  - Defined a process for specifying human/multiple agent interaction
  - Developing models associated with this process
    - Demonstration scenarios & briefings
    - Video scripts
    - Knowledge models from software
  - Will conduct design walk-thru of animocks to evaluate interaction design

Design of Multi-Agent Interaction

Stakeholders: Domain Experts, Software Engineers, Industrial Engineers, Users

Model the Domain

- Human & Agent Tasks
- Task Transitions

Stage the Story

- Human-Agent & Agent-Agent Dialog
- Task Blocking and Pacing

Enact the Scenario (Animock)

- Visualization of Human/Multi-agent Interaction
- Multi-perspective Scenarios

- Video scripts
- Knowledge models
- Demo scenarios & briefings

Design Walk-thru

Call for AAMAS Submission

- Workshop: Humans and Multi-agent Systems
  - Topics
    - Realizing and comparing models of interaction
    - Techniques and methodology supporting interaction
    - Interaction in practice
  - Submission Deadline: April 3, 2003
  - Workshop: July 14 or 15, 2003 Melbourne, Australia
    http://www.traclabs.com/~cmartin/hmas/wkshp_2003/index.html

AAAI Spring Symposium Participation

- Workshop: Human Interaction with Autonomous Systems in Complex Environments
  - How do we make people more effective and safe in performing tasks in cooperation with an autonomous system?
  - Representatives from both autonomous systems research and human-computer interaction research
  - Workshop: March 24-26, 2003 Stanford Univ., CA

    http://www.aaai.org/Symposia/Spring/2003/sss-03.html

Recent Publications

Journal

- Schreckenghost, D., C. Martin, P. Bonasso, D. Kortenkamp, T. Milam, & C. Thronesbery. Supporting group interaction among humans and autonomous agents. *Connection Science*.

Video Tape

- FY02 DCI demonstration is being videotaped for use in poster sessions and demonstrations at conferences.

Conferences

- AAAI Spring Syposium 2003
  - Martin, C., D. Schreckenghost, P. Bonasso, D. Kortenkamp, T. Milam, and C. Thronesbery. Aiding Collaboration among Humans and Complex Software Agents. AAAI Spring Symposium. Workshop on Human Interaction with Autonomous Systems in Complex Environments. March 2003.
- AAMAS 2003
  - Martin, C. E., D. Schreckenghost, R. P. Bonasso, D. Kortenkamp, T. Milam, and C. Thronesbery, "An Environment for Distributed Collaboration Among Humans and Software Agents," presented at 2nd International Conference on Autonomous Agents and Multi-Agent Systems, Melbourne, Australia, 2003. July 14-18. To appear.
- ISAIRAS 2003
  - Martin, C. E., D. Schreckenghost, R. P. Bonasso, D. Kortenkamp, T. Milam, and C. Thronesbery, "Helping Humans: Agents for Distributed Space Operations," presented at The 7th International Symposium on Artificial Intelligence, Robotics and Automation in Space, Nara, Japan, 2003. May 19-23. To appear.

Citations in Presentation

- Bahl, P. and V. N. Padmanabhan (2000). RADAR: An RF-Based In-Building User Location and Tracking System. presented at IEEE INFOCOM.

- Castro, P., P. Chiu, T. Kremenek, and R. Muntz (2001). A Probabilistic Room Location Service for Wireless Networked Environments. presented at Ubiquitous Computing, Atlanta, GA.

- Christoffersen, Klaus; George Blike; & David Woods. (2002). Making Sense of Change: How Practitioners Extract Events from Data Telemetry Streams. Institute for Ergonomics/Cognitive Systems Engineering Laboratory Report, ERGO/CSEL 02-TR-04.

- Endsley, Mica R. (1996). Automation and Situation Awareness. In Raja Parasuraman & Mustapha Mouloua (Eds.) Automation and Human Performance: Theory and Applications. Lawrence Earbaum Associates: Mahwah, N.J.

- Fitzgerald, Will; R. James Firby; & Michael Hanneman. (2003). Multimodal Event Parsing for Intelligent User Interfaces. Intelligent User Interfaces. Orlando: ACM.

- Roesler, A., M. Feil, D., Woods, A., Puskeiler, and D. Tinapple, (2001). Design tells (shares) stories about the future. Cognitive Systems Engineerning Lab, Ohio State University. (http://csel.eng.ohio-state.edu/animock/CSELanimock_web.pdf)